Subject:	INFORMATION: Policy regarding fail-safe features of structures designed to the damage tolerance requirements of § 25.571	Date:	FEB 10 1993
From:	Manager, Transport Standards Staff, ANM-110	Reply to Attn of:	
To:	Managers, ACE-100, ASW-100, ANE-100, AIR-100		

Several questions have been asked regarding fail-safe features of fuselage pressure vessel designs that incorporate crack stoppers at each panel boundary. The concern is whether integrally machined pads will provide the same level of safety as bonded doublets in the event of multiple site damage (MSD) or accidental damage.

Soon after jet airplanes started in commercial operation fatigue damage started to become a problem for the fuselage pressure vessel because of the higher stress levels associated with high altitude operations. This was especially true after several thousand pressure cycles. Crack stoppers were developed and widely used on these airplanes to prevent catastrophic explosive decompressions by confining damage to a local area. Along with the crack stoppers, other fail-safe features were also built into the design such as the ability to survive a two bay longitudinal crack with a broken central frame. Although decompression would occur with a two bay crack, sufficient residual strength would remain after depressurization to assure continued safe flight and landing.

There are no regulatory restrictions on innovative designs. The FAA cannot, however, approve any design that has features or details that experience has shown to be hazardous or unreliable. The suitability of each questionable design detail and part must be established by tests (§ 25.601). Removal of crack stoppers in the fuselage structure would result in an unreliable design unless other compensating features are present. Whether integrally machined pads are as effective as bonded doublets could be proven only after considerable full scale testing. In fact there may be some advantages in the machined pads over the bonded doublets. Bonded doublets have a long history of disbonding and trapping moisture between the doublet and the fuselage skins thus creating major corrosion problems. The real question about the integral pads is in their ability to arrest large cracks. Extensive testing must be conducted to ensure that cracks in the skin will be sufficiently retarded at the pads to provide a high probability of detection before they become catastrophic. Any interaction of the fuselage frames and stringers with the skins at the pads should also be accounted for.

A designer will often find that compromises between two or more design parameters are necessary to achieve the highest overall level of safety. In the case of fuselage skin crack stoppers, integral pads would be the preferred design if the pads provided equal crack arrest capability as crack stopper straps. Tests conducted on integral pads generally show that pads are not as effective in stopping large cracks as are straps. However, current airplane designs are experiencing about as many problems with corrosion as with fatigue damage along skin longitudinal splices and tear straps. Skin failures often result from a combination of corrosion and fatigue damage. It could be possible to achieve an overall improvement in safety with integral pads provided the pads are designed as crack stoppers, even though they might be slightly less efficient as crack stoppers. This may be the case where design compromises could produce an overall improvement in safety.

Fail safe features in fuselage skins are still required to cover accidental damage (discrete source damage) and corrosion combined with fatigue type damage. The pending regulatory requirement for two lifetimes of full scale fatigue testing should cover the MSD type fatigue damage on future airplanes for at least one lifetime. The current inspection programs are based on service history of structures having these features and predicated on the assumption that any damage will be detected before it becomes catastrophic. This is generally defined as the critical crack length associated with limit load capability or where unstable crack growth starts. If new airplane designs are significantly different from those in service today, which have accumulated many years of experience and millions of hours of operation, then the fail safety of these new designs must be completely evaluated.

Regardless of the design philosophy used by the manufacturers, they should continue the current practice of designing for a two bay crack with a broken central frame to account for the unpredictable nature of damage that might be inflicted on the fuselage, i.e. fatigue (MSD), corrosion, and accidental damage. Tests to substantiate the ability to sustain a two bay skin crack should include all the effects that influence this failure mode. Internal cabin pressure, skin shear due to fuselage down bending, and the effects of frame bending on the skin must be realistically accounted for in these tests. Of particular importance is the effects of frame bending on skin stresses. Tests conducted on pressurized barrel sections without these effects would not adequately demonstrate the ability of the skin to sustain large cracks without catastrophic results.

Signed by Gary Killion
For David G. Hmiel